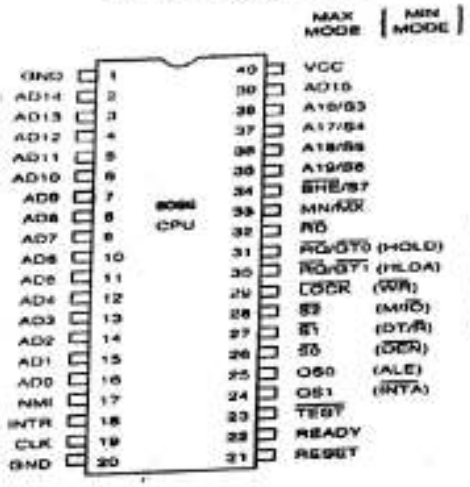
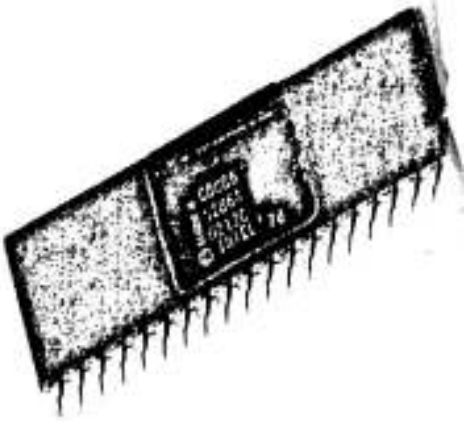
2015 - 3 - 11

University of Tripoli
Faculty of Engineering
Electrical and Electronic Engineering Department

Course Title: Introduction to Microprocessors
Prerequisite: EE234
Course No.: EE334
Time: GA: 11:00 - 12:15 Sun - Wed) GB: 12:30 - 13:45 (Sun - Wed)





Principal Textbook:

The Intel Microprocessors 8086/8088, 80186/80188, 80286, 80386, 80486, Pentium, Pentium Pro Processor, Pentium II, Pentium III, Pentium 4: Architecture, Programming and Interfacing by Barry B. Brey, Prentice Hall, 6th Edition, 2003.

Other References:

- *Microprocessors and Microcomputer –based system design*. Mohamed Rafiquzzaman , second edition ,1995.
- *The 80x86 IBM PC and Compatible Computers (Volume I and II): Assembly Language, Design and Interfacing* by Muhammad Mazidi and Janice Mazidi, Prentice Hall, 4th Edition, 2003.
- *The 8088 and 8086 Microprocessors: Programming, Interfacing, Software, Hardware and Applications* by Walter A. Triebel and Avtar Singh, Prentice Hall, 4th Edition, 2003.
- *Emu8086 Software Program*: An 8086 Assembler with integrated 8086 Microprocessor Emulator. Available at: **http://www.emu8086.com**.

EE334

Course Objectives:

The objective The objectives of this course are to give students an understanding of how a microprocessor is organized and designed, familiarize students with how microprocessors function, introduce assembly language programming, introduce microprocessor system design techniques, introduce memory system design, introduce serial and parallel I/O.

Students will develop a comprehensive understanding of the Intel® x86 instruction set and the related programming principles by writing and debugging Assembly programs that can perform I/O hardware control, basic arithmetic and BCD calculations, various logic operations and string manipulations.

Topics Covered

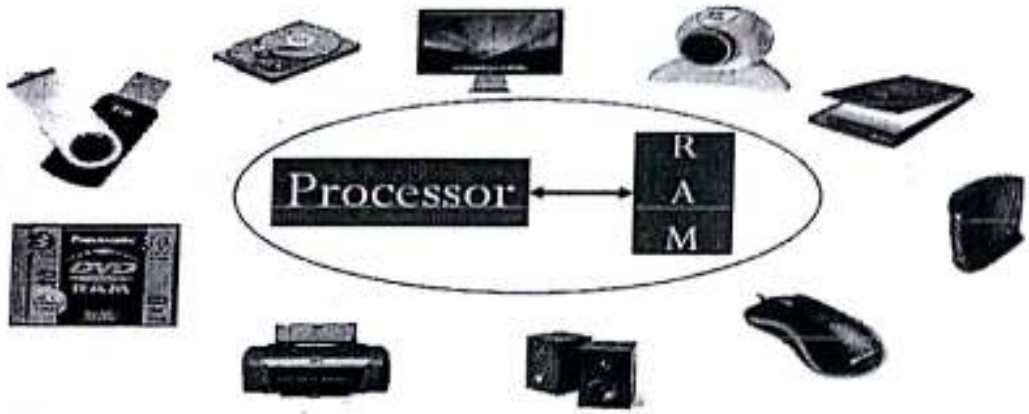
- Introduction to microprocessor and computer
- The microprocessor and its architecture
- Addressing modes
- Data movement instructions
- Arithmetic and logic instructions
- Program control instructions
- Programming the microprocessor
- Memory interface
- Basic I/O interface
- Interrupts

Grades Composition

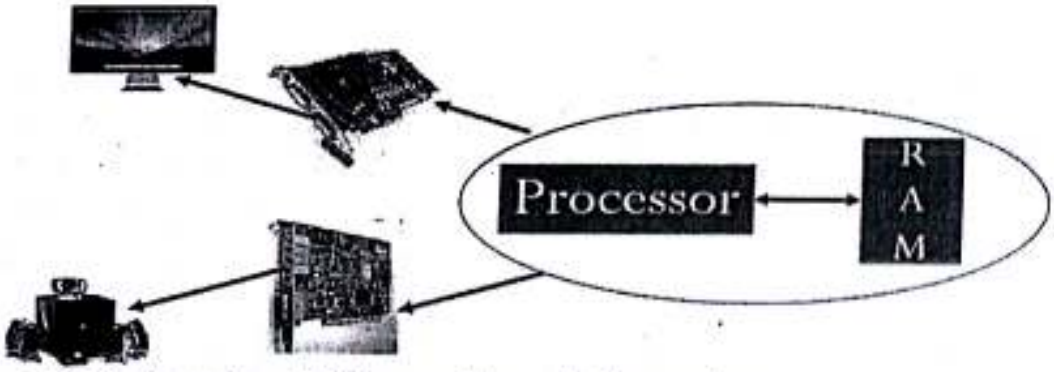
First Exam	15%
Second Exam	15%
HW & Quiz (8)	10%
Project	10%
Final Exam	50%
Total	**100%**

PC Components

- **Microprocessor**: performs all computations
- **Cache**: fast memory which holds current data and program
- **Main memory**: larger DRAM memory contains more data
- **Chipset**: controls communication between components
- **Motherboard**: circuit board which holds all the above components
- **Peripheral cards**: controls added computer accessories



- Computer Systems
  - Internal (processor + memory (RAM))
  - Peripheral (Disk, Display, Audio, Eth,..)



- Peripherals : HD monitor, 5.1 speaker
- Interfaces : Intermediate Hardware
  - Nvidia GPU card, Creative Sound Blaster card
- Interfaces : Intermediate Software/Program
  - Nvidia GPU driver . Sound Blaster Driver software

Some terms and concepts for digital computer:

Bit: a Binary digit

Byte: a group of eight bits.
Nibble: a group of four bits.
ROM: Read Only Memory.
Bus: a group of lines that carry the same type of information.
RAM: Random Access Memory. Or R/WM: Read/Write Memory.
Mnemonic: a combination of letters to suggest the operation of an instruction.
Program: a set of instructions written in a specific sequence for the computer to accomplish a given task.

Machine language: Programming language that can be directly understood and obeyed by a machine (computer) without conversion (translation).

Assembly language: Intermediate-level programming language which is higher (is easier to use but runs slower) than machine language and lower (is more difficult to use but runs faster) than a high-level language such as Basic, FORTRAN, or Java. Programs written in assembly language are converted into machine language by specialized programs called **assemblers** or compilers for their execution by the machine (computer).

Compiler: Programming language processor that translates a program written in a high-level language (the 'source program') which humans can understand, into machine language program (the 'object program') which the computers can understand

Interpreter: Computer language processor that translates a program line-by-line (statement-by-statement) and carries out the specified actions in sequence. In contrast, an assembler or compiler completely translates a program written in a high-level language (the source program) into a machine-language program (the object program) for later execution.

Assembler: Programming language processor that translates an assembly language program (the source program) to the machine language program (the object program) executable by a computer.

Some Definitions

Integrated circuits
An electronic circuit fabricated out of a solid block of semiconductor material. This design of circuit, often called a solid state circuit, allows for very complex circuits to be constructed in a small volume. An integrated circuit is also called a 'chip'.

Latches
Some microprocessors reduce the number of pins required on the chip by using the same pin for two purposes, such as using the same pins first as part of the address bus and then as part of the data bus. An external chip (a latch) is required to temporarily hold the address bus value.

I/O Interfaces
I/O interfaces are used to read and write data to storage and I/O devices such as keyboards, printers, disk drives, etc. Serial interfaces transfer one bit at a time while parallel interfaces transfer several (typically 8) bits at a time.

DRAM Refresh
Dynamic RAM (a type of Random-Access Memory) stores data as electric charge in a capacitor.
DRAM requires that every memory cell's content be "refreshed" periodically by recharging the capacitor. Circuits are required to ensure that the DRAM contents are periodically refreshed.

Cache Memory
Many modern microprocessors require faster access to memory than is possible with inexpensive memory devices. Fast auxiliary memories called cache memories are used to store the contents of frequently used memory locations and thus improve the overall performance of the system.

Based on the instruction set microprocessors are classified into:

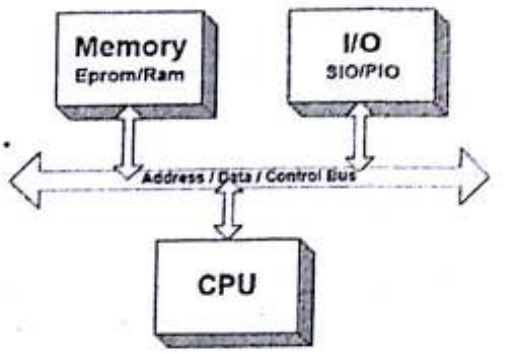
- **RISC** — Reduced Instruction Set Computing. These types of processors are commonly used in ovens, air conditioners, etc.
- **CISC** — Complex Instruction Set Computing. The types of processors are used in desktops, laptops and servers.

Microcomputer

- The particular microprocessor-based systems that happen to be used as a computer are called microcomputers. The additional circuits required for a computer can be built into the same integrated circuit giving rise to a single chip microcomputer.

- A digital computer, in which one microprocessor has been provided to act as a CPU, is called Microcomputer.
- a computer with a microprocessor as its CPU. Includes memory, I/O etc.

- A desktop computer, laptop, notebook, palmtop, etc, contain one microprocessor to act as a CPU and hence they come under the category of microcomputer.



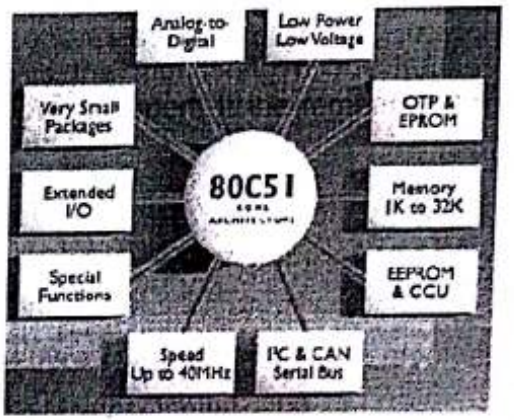
MicroComputer

A Microcontroller is a Microcomputer in a single Chip. That means that a microcontroller chip includes a microprocessor (CPU) as well as some often used peripherals. A controller is used to control (makes sense!) some process or aspect of the environment. A typical microcontroller application is the monitoring of my house. As the temperature rises, the controller causes the windows to open. If the temperature goes above a certain threshold, the air conditioner is activated.

Microcontroller

It typically includes:

- CPU (central processing unit or the microprocessor)
- EPROM/PROM/ROM (Read Only Memory for the program code)
- RAM (Random Access Memory for the data)
- I/O (input/output) devices (serial, parallel, ADC, DAC etc.)
- Timers
- Interrupt controller



Multiprocessor System:

- The CPU of a large powerful digital computer contains more than one microprocessor.
- High-end powerful servers, mainframe computers, supercomputers, etc. contain more than one microprocessor to act as CPU.

Basic Concepts of Microprocessors

- **What is a microprocessor?**

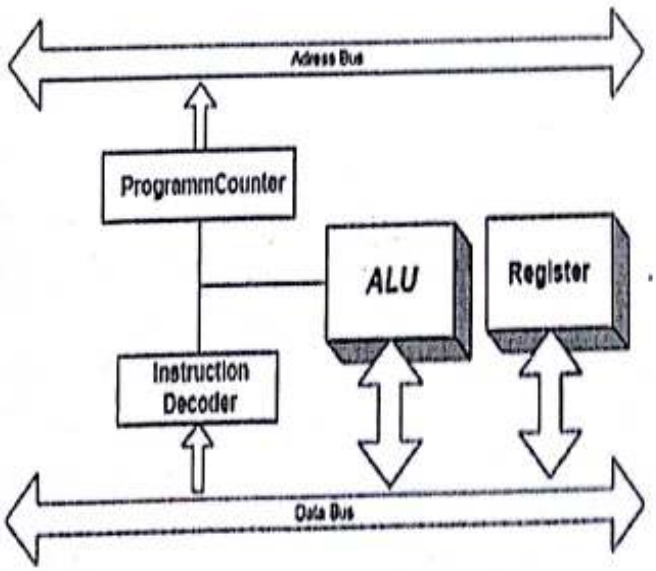
The word comes from the combination **micro** and **processor**.

– **Processor** means a device that processes whatever. In this context processor means a device that processes numbers, specifically binary numbers, 0's and 1's.

Microprocessor: A silicon chip that contains a CPU. In the world of personal computers, the terms microprocessor and CPU are used interchangeably.

Microprocessor (sometimes abbreviated µP) is a digital electronic component with miniaturized transistors on a single semiconductor integrated circuit (IC).

Microprocessor is an IC (integrated circuit) that contains most of the digital logic required to implement a computer except for memory and I/O (input/output) devices.
Microprocessor: silicon chip which includes ALU, register circuits & control circuits. A CPU does not include any memory or I/O components.



Microcontrollers Vs Microprocessors

1. A microprocessor requires an external memory for program/data storage. Instruction execution requires movement of data from the external memory to the microprocessor or vice versa. Usually, microprocessors have good computing power and they have higher clock speed to facilitate faster computation.

2. A microcontroller has required on-chip memory with associated peripherals. A microcontroller can be thought of a microprocessor with inbuilt peripherals.

3. A microcontroller does not require much additional interfacing ICs for operation and i functions as a **stand alone** system. The operation of a microcontroller is multipurpose.

Stand-alone:

- able to operate without control from another system.

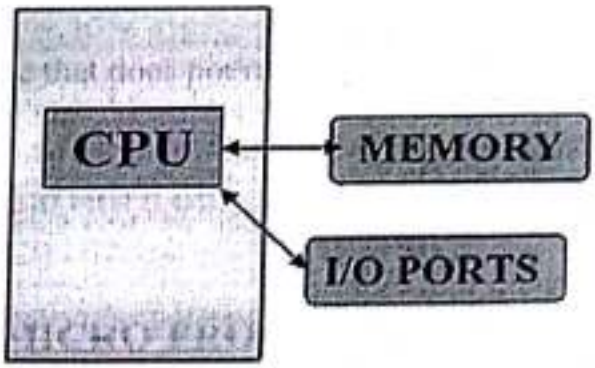
- Refers to a device that is self-contained, one that does not require any other devices to function. For example, a fax machine is a stand-alone device because it does not require a computer, printer, modem, or other device. A printer, on the other hand, is not a stand-alone device because it requires a computer to feed it data.

MICRO CONTROLLER

- It is a single chip
- Consists Memory, I/o ports

MICRO PROCESSER

- It is a CPU
- Memory, I/O Ports to be connected externally



Evolution of Microprocessor:

- The first microprocessor Intel 4004, a 4 bit PMOS microprocessor, was introduced in the year 1971 by Intel Corporation, USA. After this a 4-bit microprocessor Intel 4040, and advanced version of Intel 4004 was developed.

- In 1972 Intel introduced the 1st 8 bit microprocessor, Intel 8008 which also used PMOS technology, the microprocessor using PMOS technology were slow and not compatible with TTL logic.

- In 1972 Intel introduced a more powerful and faster 8bit NMOS microprocessor Intel 8080. The microprocessor using NMOS technology also provides higher density as compared to PMOS technology.

- In 1975 Intel developed an improved 8bit NMOS microprocessor, Intel 8085, which uses only one +5v power supply. It is improved version of Intel 8080.

- In the year 1978 Intel introduced a 16 bit microprocessor **Intel 8086**. Other examples of 16 bit microprocessors are Intel 80186, 8088, 80188, 80286, zilog's Z-8000, Motorola's 6800, 68010. The 80186 and 80188 are Integrated microprocessor.

- In the year 1985 Intel introduced a more powerful 32 bit Microprocessor and Intel 80386 which became very popular and was used in desktop computers.

Intel® PC-based Microprocessor Summary

Processor Name	Release Date[1]	No. of Transistors	Min. Clock Speed	Register Data Width	Data Bus Width	Address Bus Width	MIPS
4004	1971	2,300	740 KHz	4 bits	4 bits	12 bits	0.05
8008	1972	3,500	500 KHz	8 bits	8 bits	14 bits	0.05
8080	1974	6,000	2 MHz	8 bits	8 bits	16 bits	0.5
8085	1976	6,500	5 MHz	8 bits	8 bits	16 bits	0.77
8086	1978	29,000	5 MHz	**16 bits**	16 bits	20 bits[5]	2.5
8088	1979	29,000	5 MHz	16 bits	8 bits[6]	20 bits	2.5
80186[4]	1982	-	-	16 bits	16 bits	20 bits	-
80286	1982	134,000	8 MHz	16 bits	16 bits	24 bits	4
80386	1985	275,000	16 MHz	**32 bits**	32 bits	32 bits[8]	5
80486[7]	1989	1.2 M	25 MHz	32 bits	32 bits	32 bits	20
Pentium	1993	3.1 M	60 MHz	32 bits	64 bits	32 bits	110
Pentium II	1997	7.5 M	233 MHz	32 bits	64 bits	36 bits[9]	~300
Pentium III	1999	9.5 M	450 MHz	32 bits	64 bits	36 bits	~510
Pentium 4	2000	42 M	1.5 GHz	32 bits	64 bits	36 bits	~1,700
Pentium 4 Extreme Edition	2004	171 M	3.2 GHz	64 bits	64 bits	64 bits[10]	~9,700

7.5 G transistor

Latest microprocessor details...

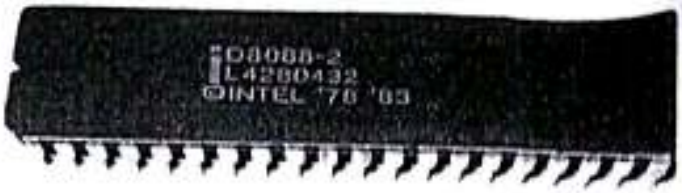
Pentium 4	2005	125 M	0.09	3.8 GHz	32 bits	64 bits	36 bits	11,000
P4EE	2005	178 M	0.09	3.73 GHz	64 bits	64 bits	64 bits	15.000

In addition to the above microprocessors, Intel® produces some other types, such as:

- **Intel® Pentium® M:** The Pentium M was built to maximize both performance and battery life, and is suitable for light-weight notebooks. It is usually a component of the new Intel Centrino®[11] notebook platform.
- **Intel® Pentium® D:** This is a dual-core processor with two execution cores in one physical processor.

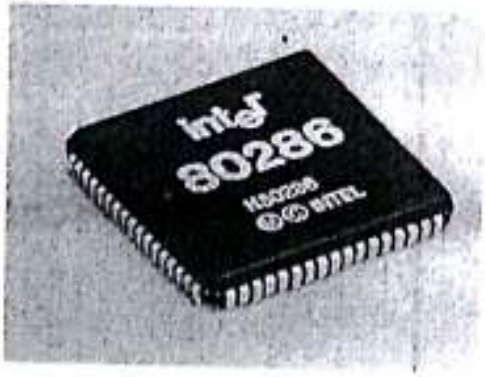
Note :- (The 8086 microprocessor is one of the family of 80186,80286,80386,80486,Pentium,PentiumI,II,III .... Also referred to as the X86 family.)

Intel 8086



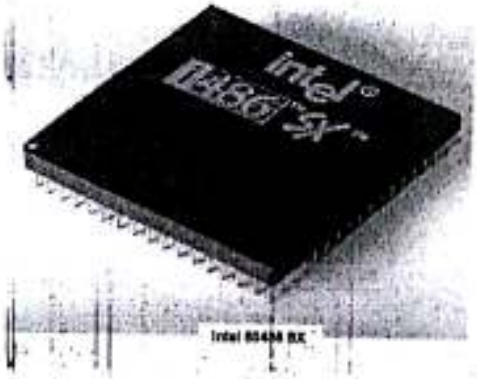
Intel 8088

Intel 80186

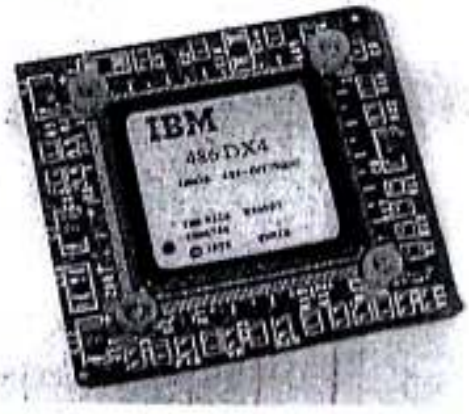


Intel 80286

Intel 80386 SX



Intel 80486 SX



Microprocessor Characteristics

Clock Speed

- The clock speed determines how many operations per second the processor can perform.
- It is also called Clock Rate.
- Clock speeds are expressed in megahertz (MHz) or gigahertz (GHz).
- The microprocessors of personal computers have clock speeds of anywhere from 300 MHz to over 3.8 GHz.

Word Length:

- It depends upon the width of internal data bus, registers, ALU etc.
- An 8-bit microprocessor can process 8 bit data at a time.
- A processor with longer word length is more powerful and can process data at a faster speed as compared to processor with shorter word length.
- The word length ranges from 4 bits for small microprocessor, to 64 bits for high-end microcomputers

Width of Data Bus:

- This is the size of the data bus. It defines the number of bits that can be transferred through data bus.

Width of Address Bus:

- This parameter decides the memory addressing capability of the microprocessor. The maximum size of the memory unit is decided by this parameter.

Input/Output Addressing Capability:

- The maximum number of the input/output ports accessed by the microprocessor depends upon the width of the input/output address provided in the input/output instruction.

Data Types:

- The microprocessor handles various types of data formats like binary, BCD, ASCII, signed and unsigned numbers.

Interrupt Capability

- Interrupts are used to handle unpredictable and random events in the microcomputer.
- It is used to interrupt the microprocessor.
- Interrupt driven input/output improves the throughput of a system.

Performance

Clock Cycles

When the clock transitions from a "0" to a "1" it is called the **positive edge**, and when the clock transitions from a "1" to a "0" it is called the **negative edge**. The time it takes to go from one positive edge to the next positive edge is know as the **clock period**, and represents one **clock cycle**.

Clock Frequency

The number of clock cycles that can fit in 1 second is called the **clock frequency**. To get the clock frequency, we can use the following formula:

$$\text{Clock Frequency} = \frac{1}{\text{Clock Period}}$$

Clock frequency is measured in units of ***cycles per second***.

Cycles per Instruction

The number of cycles are required to perform a single instruction is known as the **cycles per instruction**, or **CPI** of the processor. It is more useful to compare the number of **instructions per second**, which can be calculated as such:

$$\text{Instructions per Second} = \frac{\text{Clock Frequency}}{CPI}$$

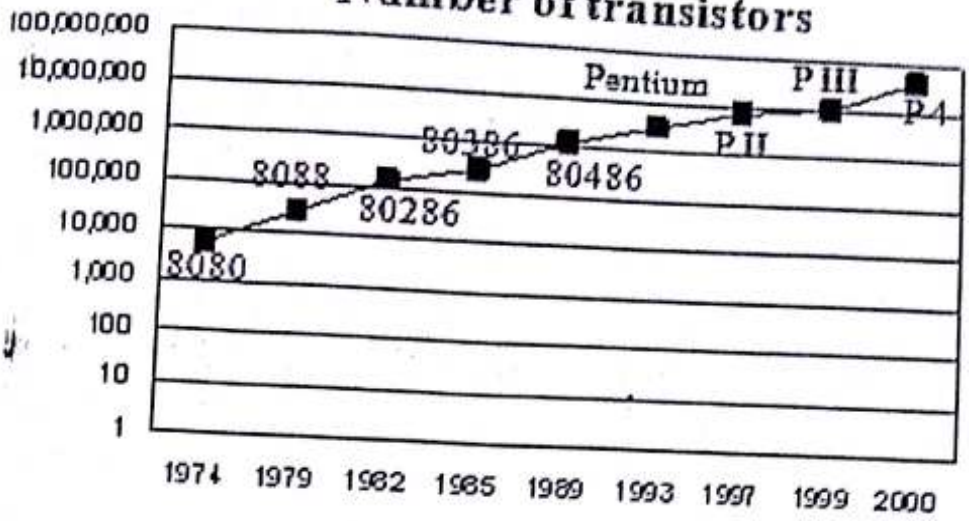
One of the most common units of measure in modern processors is the "MIPS", which stands for millions of instructions per second. Processor with 5 MIPS can perform 5 million instructions every second.

CPU Time

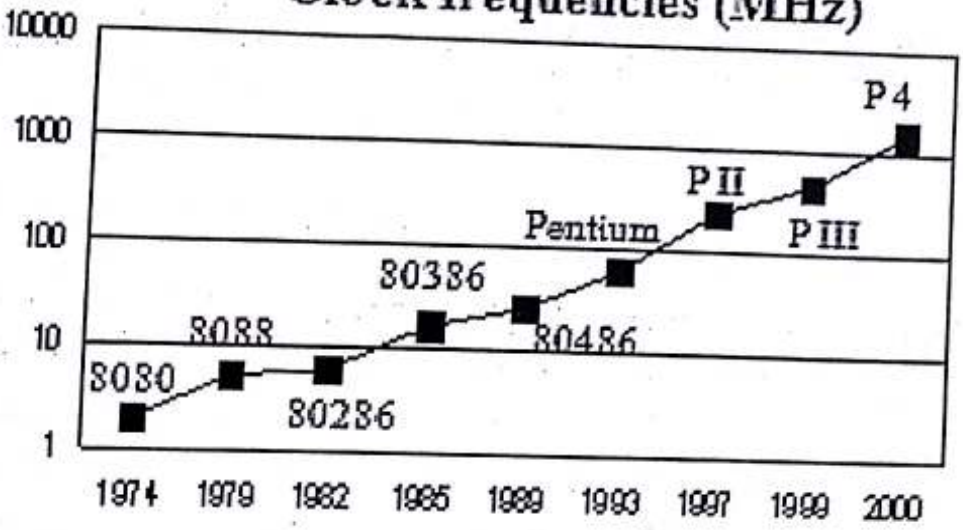
CPU Time is the amount of time it takes the CPU to complete a particular program. CPU time is a function of the amount of time it takes to complete instructions, and the number of instructions in the program:

$$\text{CPU time} = \text{Instruction Count} \times CPI \times \text{Clock Cycle Time}$$

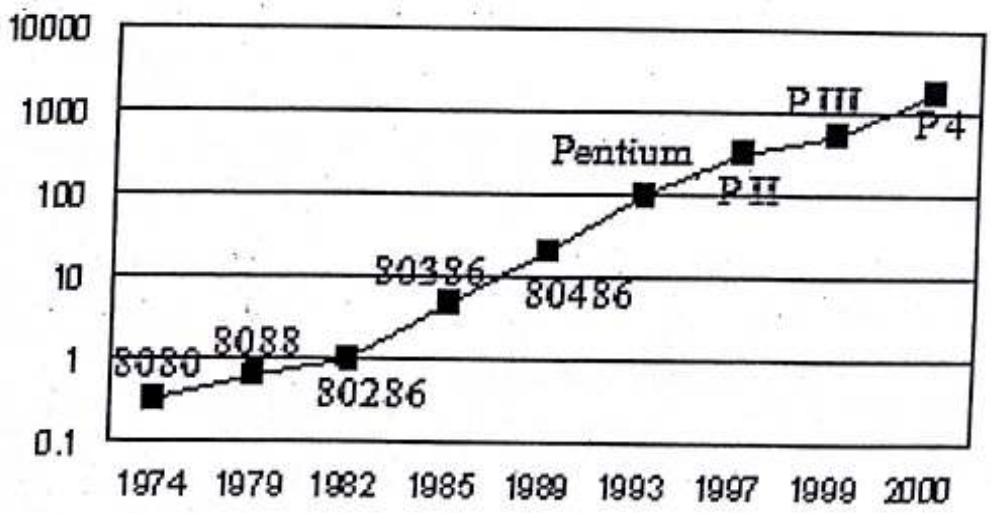
Number of transistors



Clock frequencies (MHz)



MIPS



Definition of the Microprocessor

The **microprocessor** is a **programmable device** that **takes in numbers**, performs on them arithmetic or logical operations according to the program stored in memory and then Produces other numbers as a result.

Programmable device: The microprocessor can perform different sets of operations on the data it receives depending on the sequence of **instructions** supplied in the given program.

Instructions: Each microprocessor is designed to execute a specific group of operations. This group of operations is called an instruction set. This instruction set defines what the microprocessor can and cannot do.

Takes in: The data that the microprocessor manipulates must come from somewhere.

- It comes from what is called "input devices".
- These are devices that bring data into the system from the outside world.
- These represent devices such as a keyboard, a mouse, switches, and the like.

Numbers: The microprocessor has a very narrow view on life. It only understands binary numbers.
A binary digit is called a bit (which comes from **b**inary **d**igit).

- A group of 8-bits were referred to as a "half-word" or "**byte**".
- A group of 4 bits is called a "**nibble**".
- Also, 32 bit groups were given the name "**long word**".

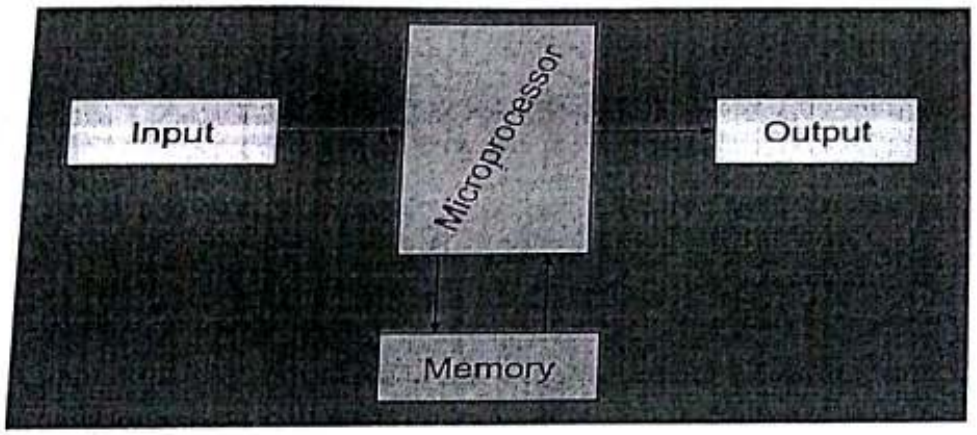
Some important terminology:

bit	0
nibble	0000
byte	0000 0000
word	0000 0000 0000 0000
double-word	0000 0000 0000 0000 0000 0000 0000 0000
quad-word	0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000

1 kilobyte is 2^{10} bytes.
1 megabyte is 2^{20} bytes.
1 gigabyte is 2^{30} bytes (over 1 trillion)
1 terabyte is 2^{40} bytes

A Microprocessor-based system

From the above description, we can draw the following block diagram to represent a microprocessor-based system. The block diagram is composed of three blocks that are interconnected by buses.
A **Bus** is a set of common connections that carry the same type of information.



The CPU is connected to memory and I/O devices through a strip of wires called a **bus**. The bus inside a computer carries information from place to place. In every computer there are three types of busses:

1. *Address Bus:*

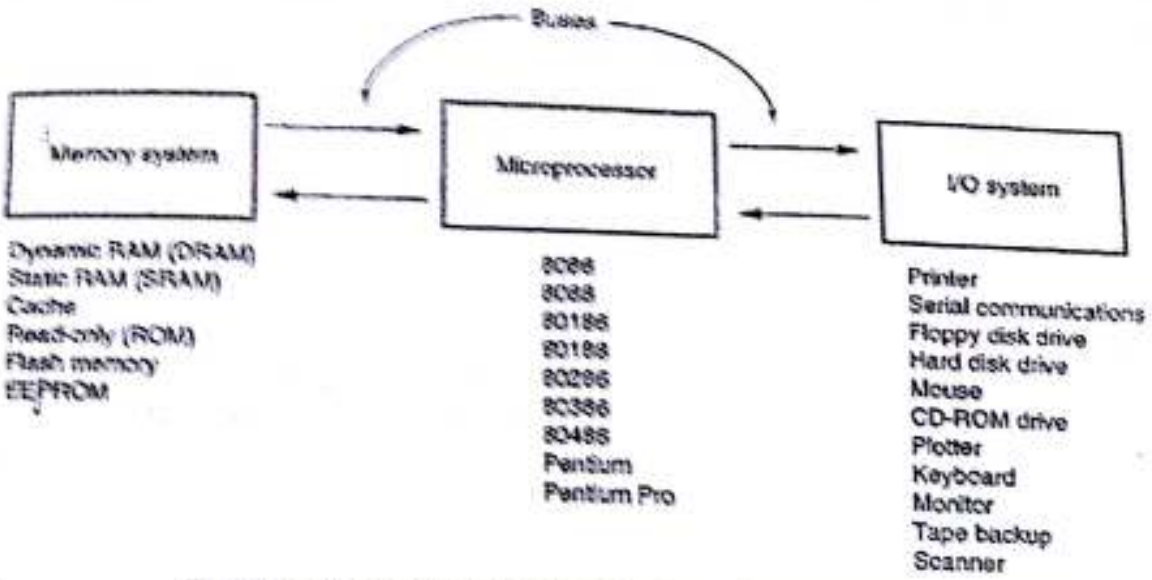
The address bus is used to identify the memory location or I/O device the processor intends to communicate with. The width of the Address Bus rages from 20 bits (8086) to 36 bits for (Pentium II).

2. *Data Bus:*

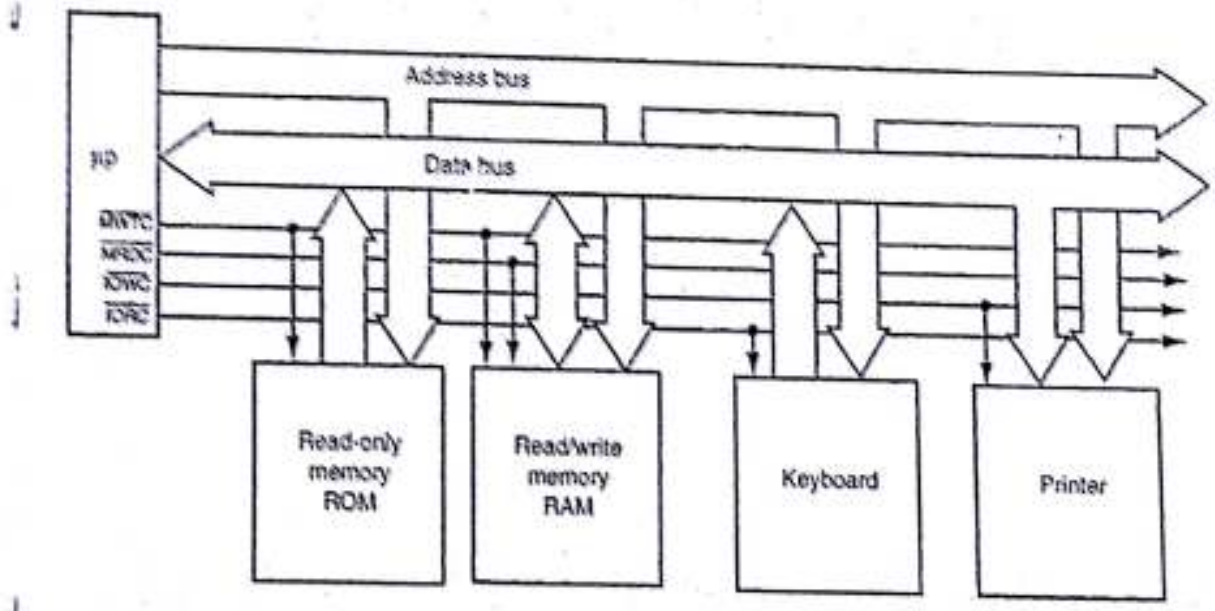
Data bus is used by the CPU to get data from / to send data to the memory or the I/O devices. The width of a microprocessor is used to classify the microprocessor. The size of data bus of Intel microprocessors vary between 8-bit (8085) to 64-bit (Pentium).

3. *Control Bus.*

How can we tell if the address on the bus is memory address or an I/O device address? This where the control bus comes in. Each time the processor outputs an address it also activates one of the four control bus signals: Memory Read, Memory Write, I/O Read and I/O Write.
The address and control bus contains output lines only, therefore it is **unidirectional**, but the data bus is **bidirectional.**



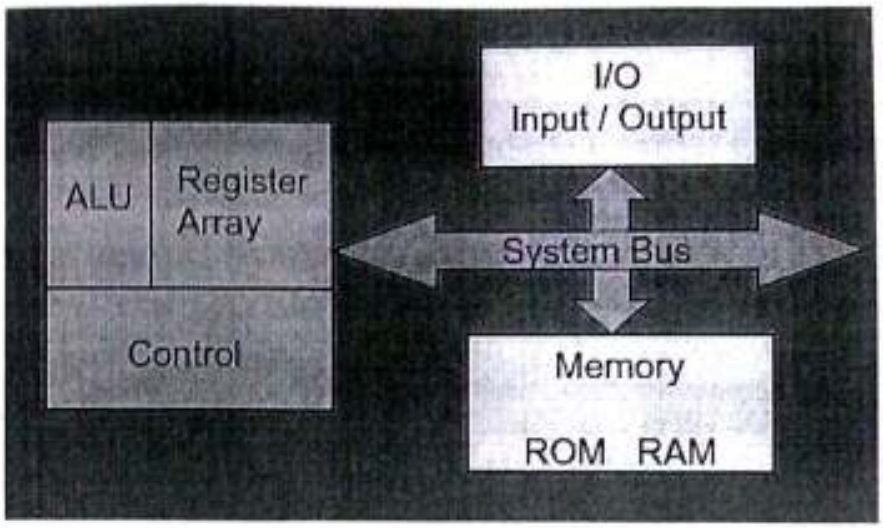
The block diagram of a microprocessor-based computer system

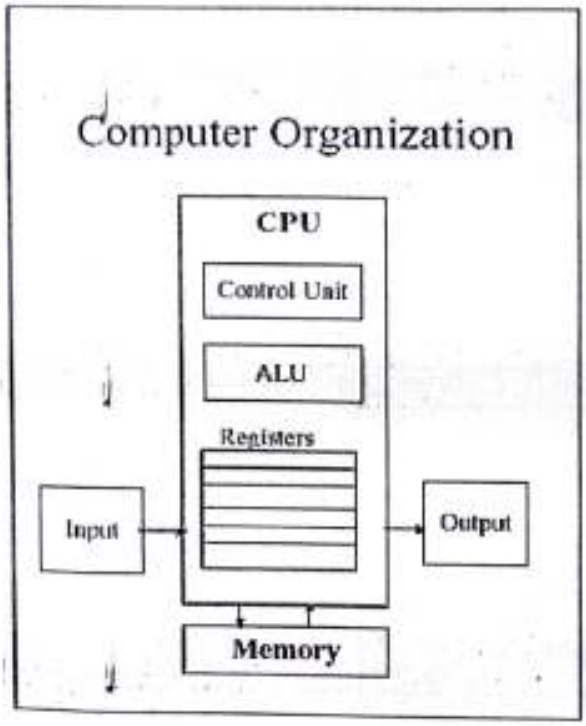


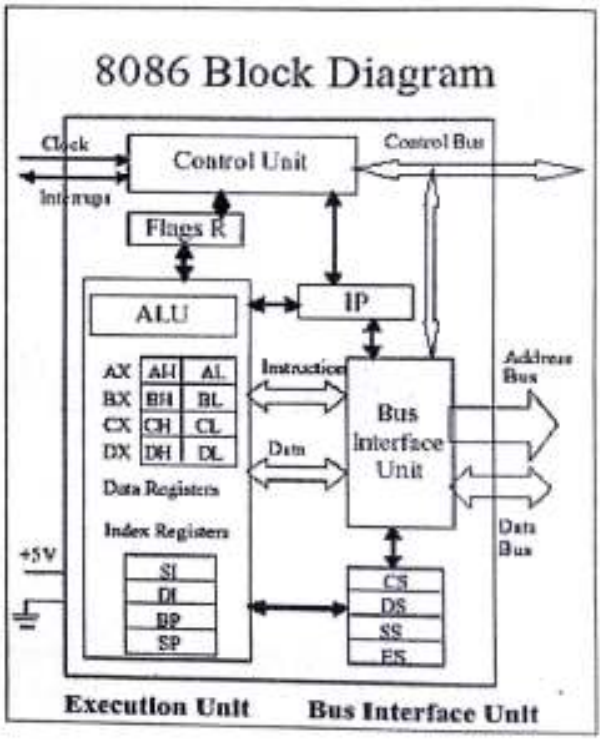
Four main control lines

- **MRDC** (memory read control)
- **MWTC** (memory write control)
- **IORC** (I/O read control)
- **IOWC** (I/O write control)

Organization of a microprocessor- based system

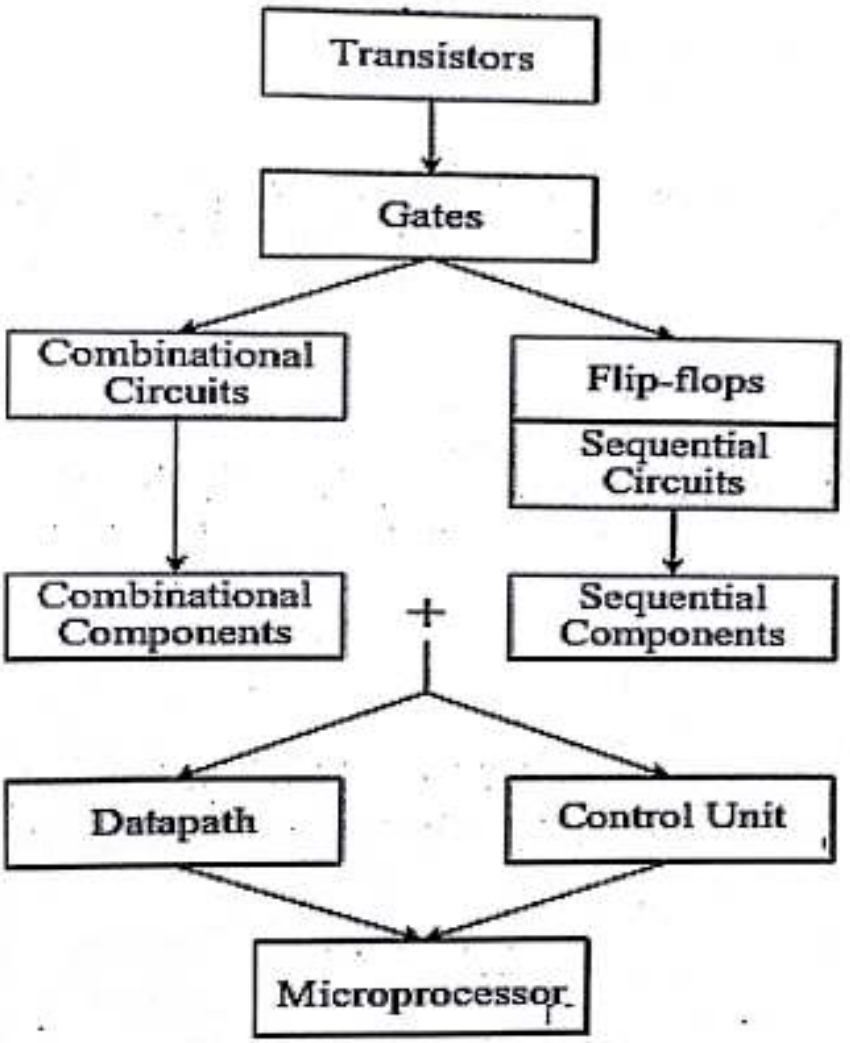






The following figure summarizes how the different parts and components fit together to form the **microprocessor**. From **transistors, logic gates** are built. Logic gates are combined together to form either combinational circuits or **sequential circuits.**

There are combinational circuits and sequential circuits that are used as standard building blocks for larger circuits such as the **microprocessor**



A data path

(also written as datapath) A data path is a collection of functional units, for example, arithmetic logic units or multipliers, which carry out data processing operations. The function of data paths is to provide routes for data to travel between functional units. More often than not, central processing units consist of a data path and a control unit.

There are three major parts of a Computer System.

1. Central Processing Unit (CPU)
Also simply called as the microprocessor and acts as the brain coordinating all activities within a computer.

2. The Memory:
The program instructions and data are primarily stored.

3. The Input/Output (I/O) Devices:
Allow the computer to input information for processing and then output the results. I/O Devices are also known as computer peripherals.

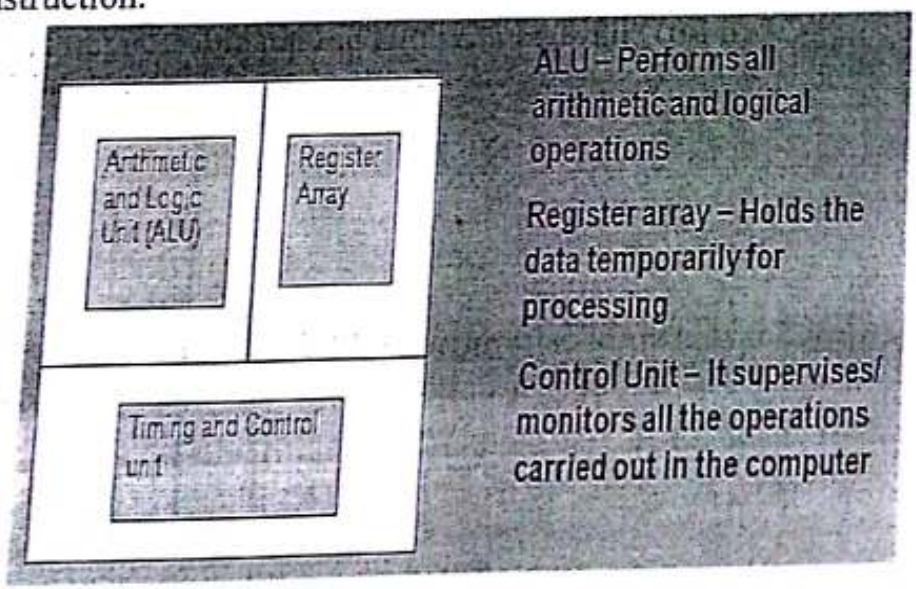
Inside the CPU

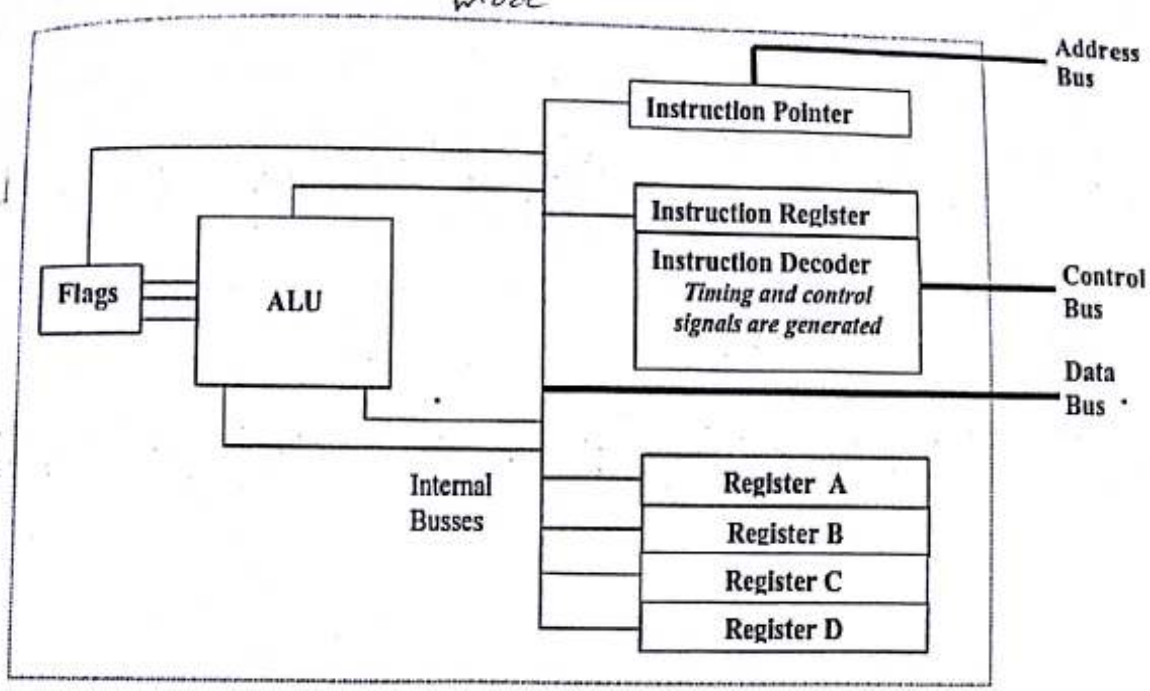
1. The CPU contains a number of ***registers*** to store information inside the CPU temporarily. Registers inside the CPU can be 8-bit, 16-bit, 32-bit or even 64-bit depending on the CPU.

2. The CPU also contains ***Arithmetic and Logic Unit (ALU).*** The ALU performs arithmetic (add, subtract, multiply, divide) and logic (AND, OR, NOT) functions.

3. The CPU contains a ***program counter*** also known as the ***Instruction Pointer*** to point the address of the next instruction to be executed.

4. ***Instruction Decoder*** is a kind of dictionary which is used to interpret the meaning of the instruction fetched into the CPU. Appropriate control signals are generated according to the meaning of the instruction.





Internal block diagram of a CPU

Memory

- Memory is a collection of storage devices. Usually, each storage device holds one bit. Also, in most kinds of memory, these storage devices are grouped into groups of 8. These 8 storage locations can only be accessed together. So, one can only read or write in terms of bytes to and from memory.

- Microcomputer memory can be logically divided into three groups:

  1- Process memory (Registers)

  2- Primary memory (ROM – RAM)

  3- Secondary memory (Magnetic taps and disks)

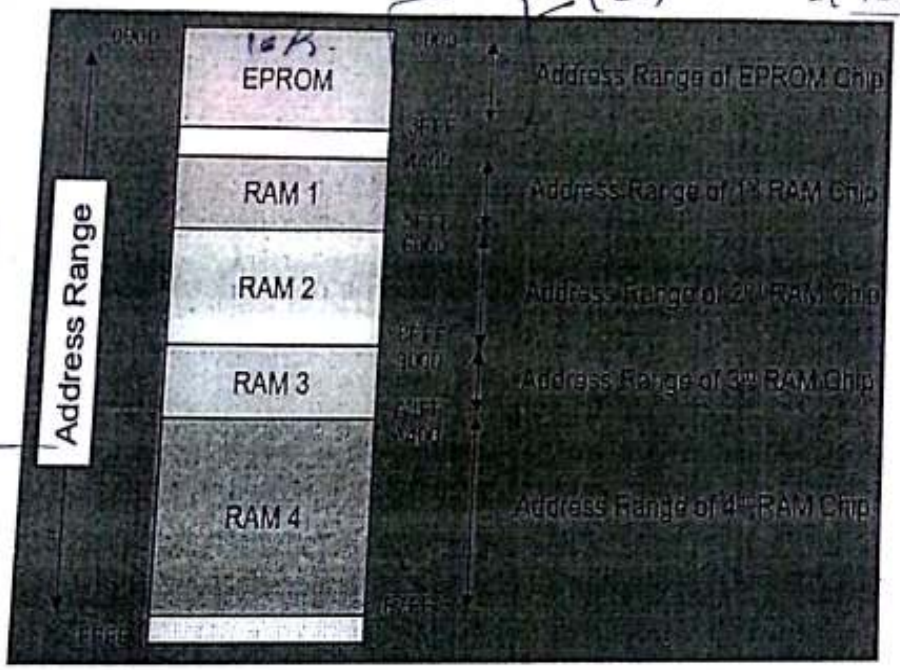
Stored in memory:

- When a program is entered into a computer, it is stored in memory. Then as the microprocessor starts to execute the instructions, it brings the instructions from memory one at a time.

- The microprocessor reads (brings in) the data from memory when it needs it and writes (stores) the results into memory when it is done.

Produces:

- For the user to see the result of the execution of the program, the results must be presented in a human readable form.
- The results must be presented on an output device.
- This can be the monitor, a paper from the printer, a simple LED or many other forms.
- The **memory map** is a picture representation of the address range and shows where the different memory chips are located within the address range.



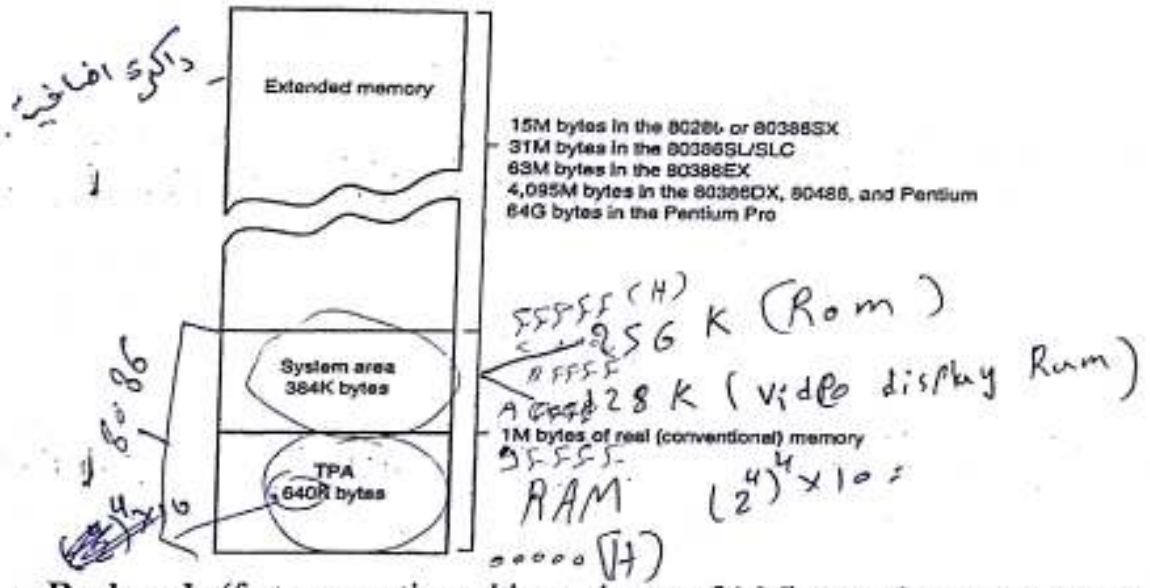
Processor	Address lines	Memory	Address Map
8086/8088	20	1 M byte	00000H- FFFFFH
80286/80386SX	24	16M byte	000000H- FFFFFFH
80386SL	25	32M byte	0000000H-1FFFFFFH
80386DX 80486 Pentium	32	4 G byte	00000000H-FFFFFFFFH

The memory map of the Personal Computer

- The memory system is divided into three main parts: **TPA** (Transient Program Area), **system area**, and **XMS (Extended Memory System).** The type of microprocessor in your computer determines whether an extended memory system exists. If the computer is based upon an older 8086 or 8088 (a PC or XT), the TPA and system areas exist, but there is no extended memory area.

- The PC and XT contain 640K bytes of TPA and 384K bytes of system memory, for a total memory size of 1 M bytes. We often call the first IM byte of memory the ***real or conventional memory*** system because each Intel microprocessor is designed to function in this area by using its real mode of operation.

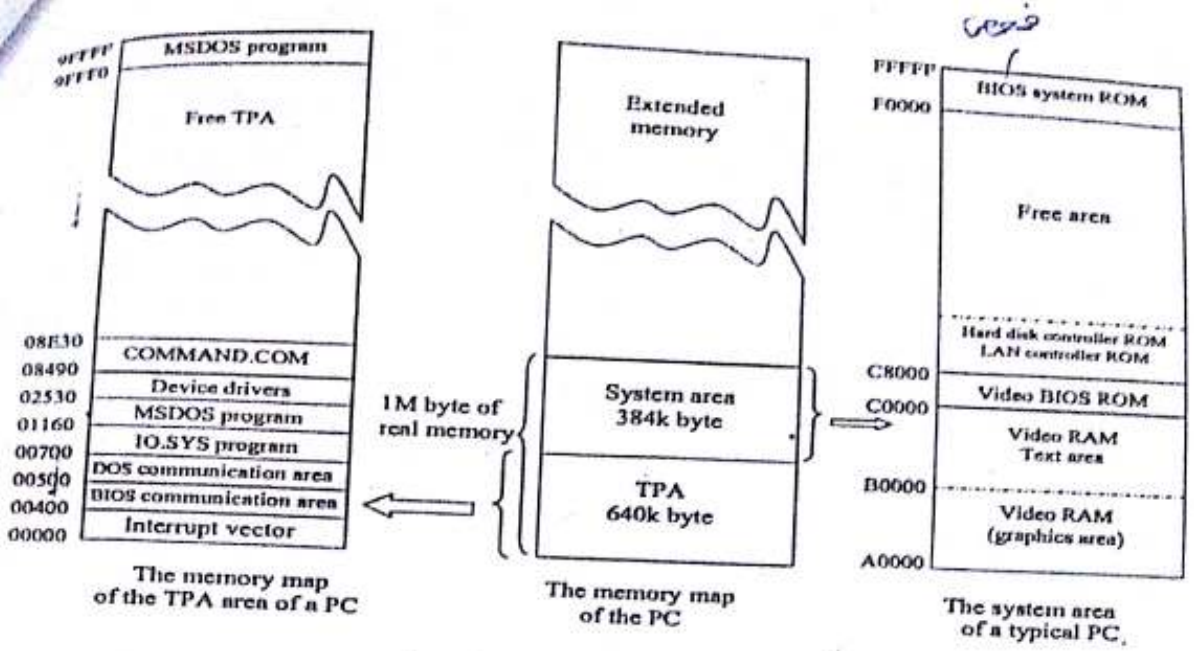
Computer systems based on the 80286 through the Pentium 4 not only contain the TPA (640K bytes) and system area (384K bytes), they also contain extended memory. These machines are often called AT class machines.



- **Real mode** (faster operation with maximum of 1 Mbytes of memory) but the **Protected mode** is slower but can use 16 Mbytes of memory.

- The TPA: The transient program area (TPA) holds the DOS operating system and other programs that control the computer system. The TPA also stores DOS application programs. The length of the TPA is 640K bytes.

- The System Area: The system area contains program on either a ROM or flash memory, and areas of RAM for data storage.



The memory map of the TPA area of a PC

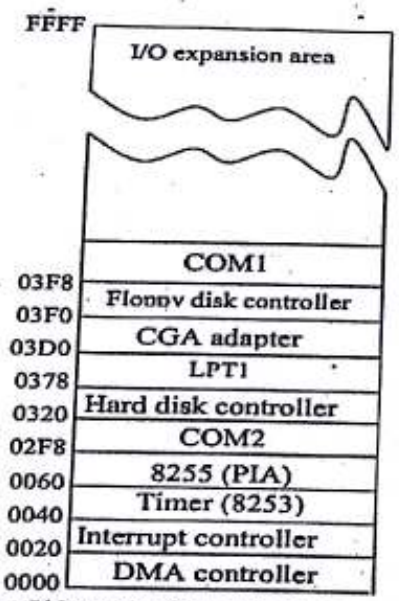
The memory map of the PC

The system area of a typical PC

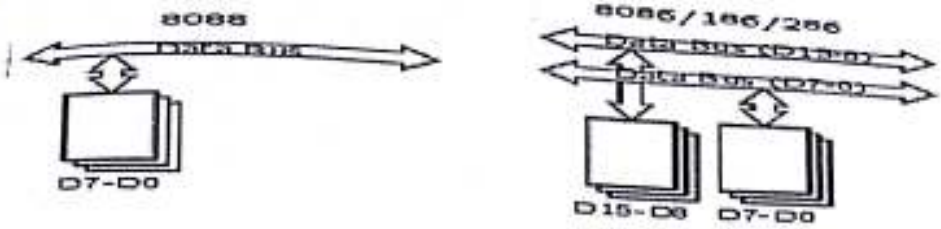
- I/O devices:

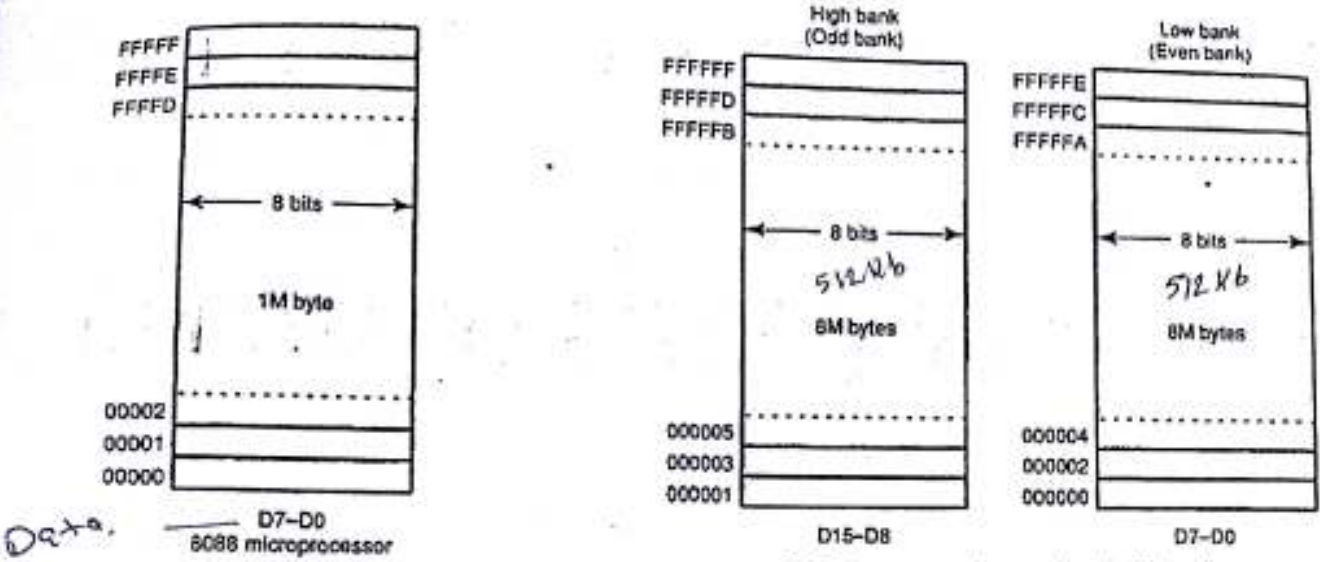
The I/O devices allow the microprocessor to communicate between itself and the outside world. The I/O space in a computer system extends from port 0000H to port FFFFH The I/O space allows the computer to access up to 64K different 8-bit I/O devices.

The I/O area contains two major sections. The area below I/O location 0400H is considered reserved for system devices. The remaining area is available I/O space for expansion on newer devices.

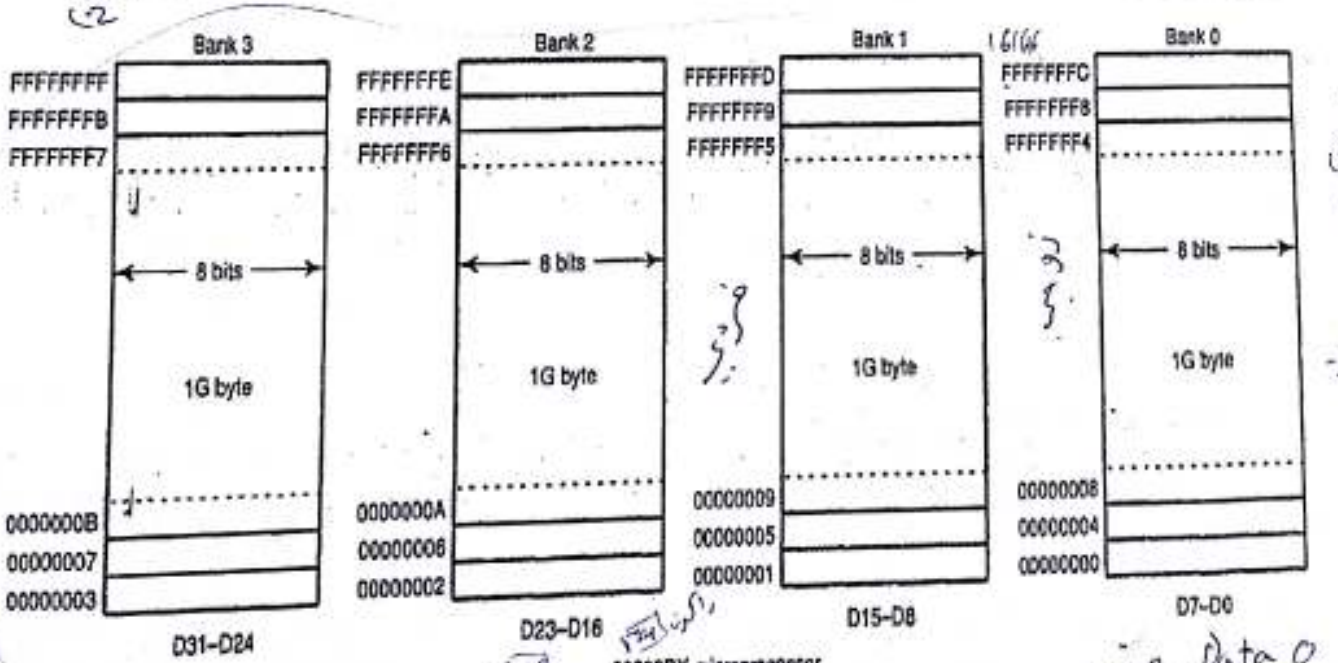


The I/O map of a personal computer



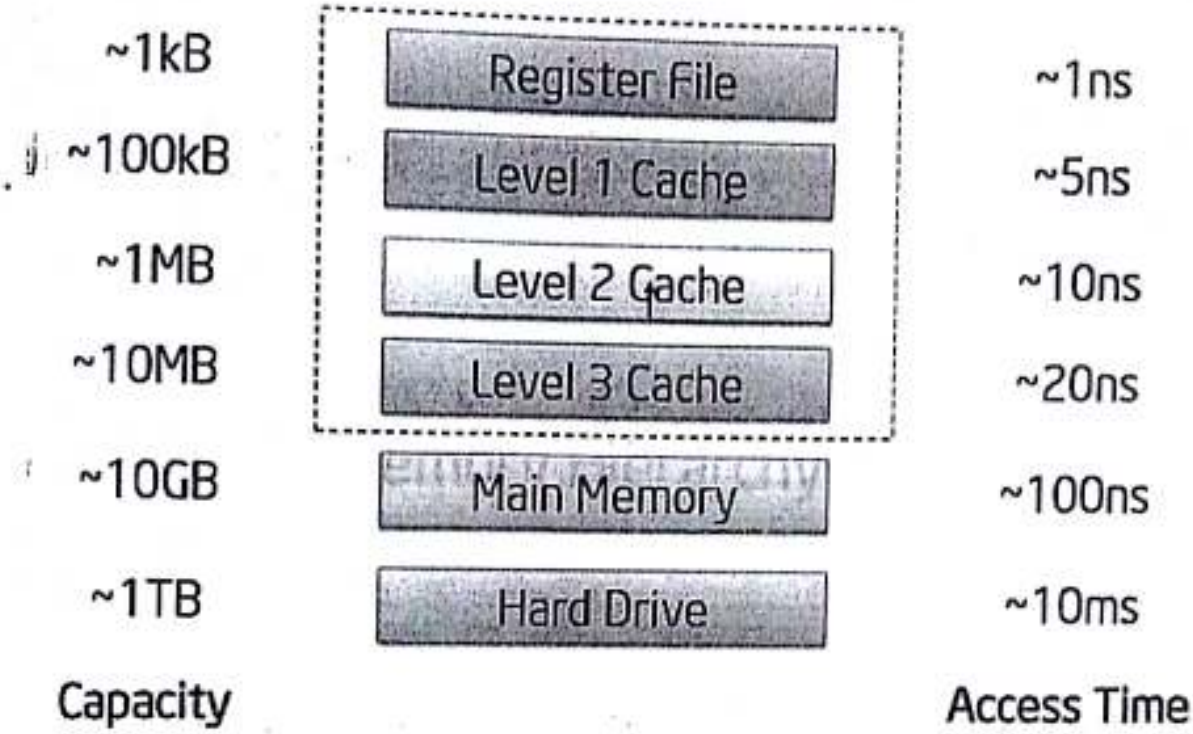


8086 microprocessor (memory is only 1M bytes)
80286 microprocessor
80386SX microprocessor
80386SL microprocessor (memory is 32M bytes)
80386SLC microprocessor (memory is 32M bytes)

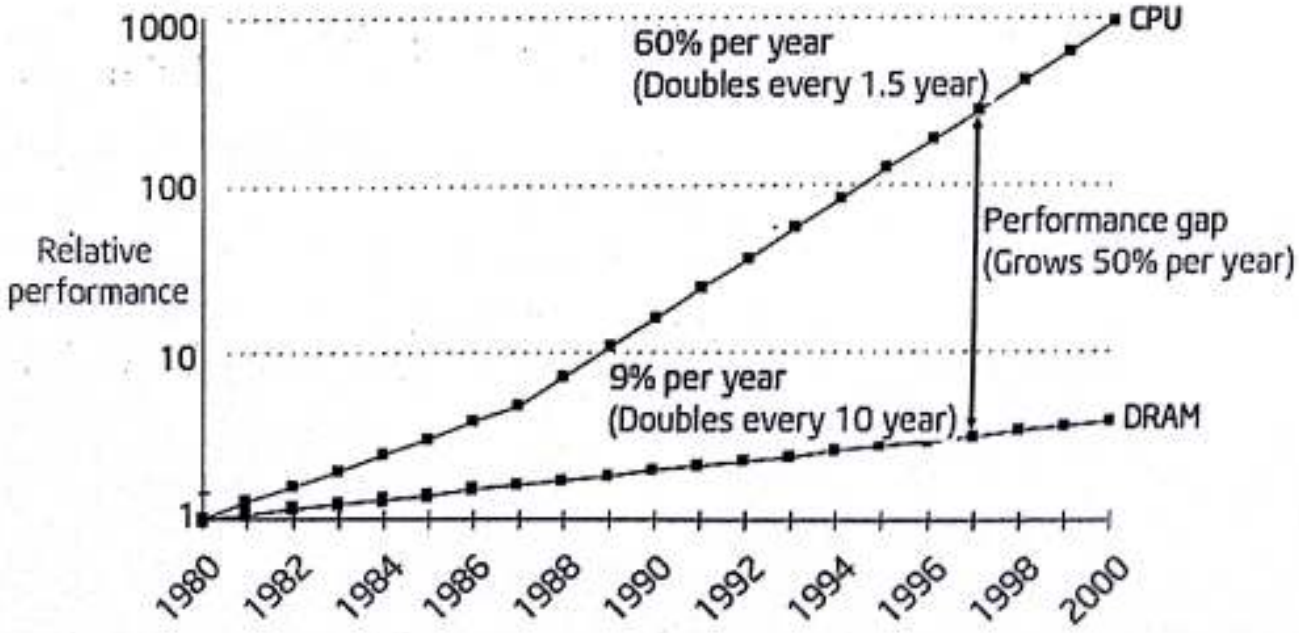


80386DX microprocessor
80486SX microprocessor
80486DX microprocessor

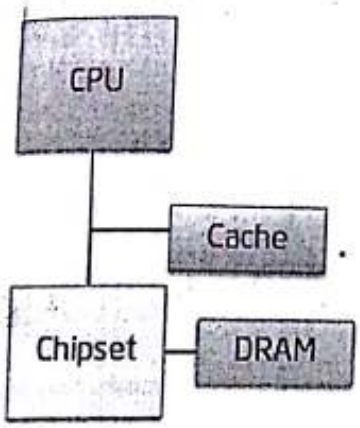
Memory Hierarchy



Processor-Memory Performance Gap

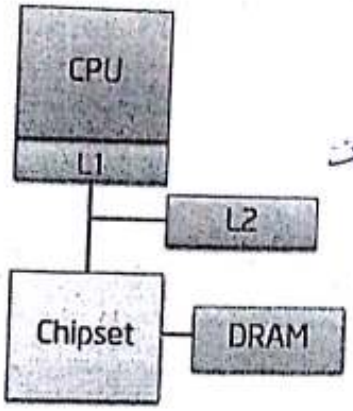


Memory Hierarchy Evolution



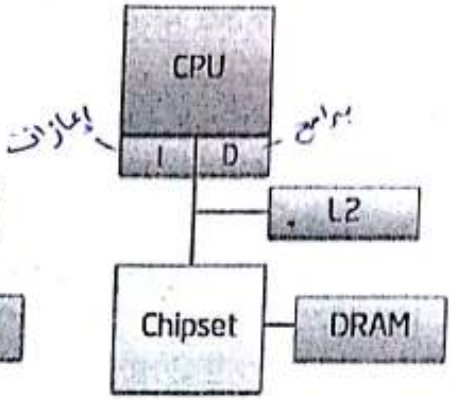
386

No on-die cache.
Level 1 cache
on motherboard



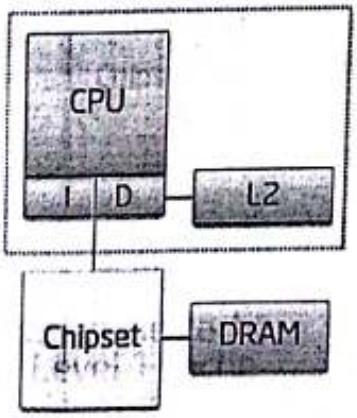
486

Level 1 cache on-die.
Level 2 cache
on motherboard



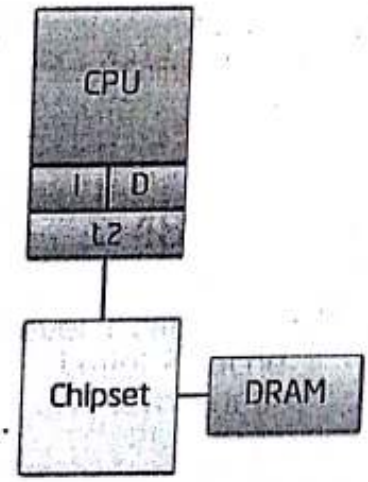
Pentium

Separate Instruction
and Data Caches



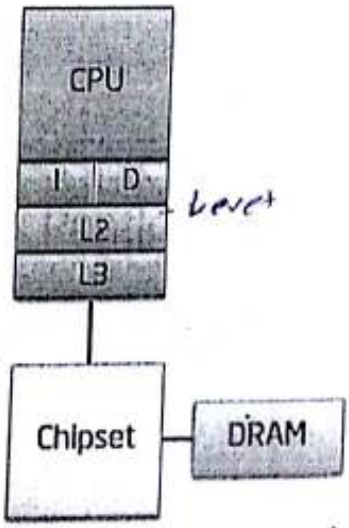
Pentium II

Separate bus to L2
cache in same
package



Pentium III

L2 cache on-die



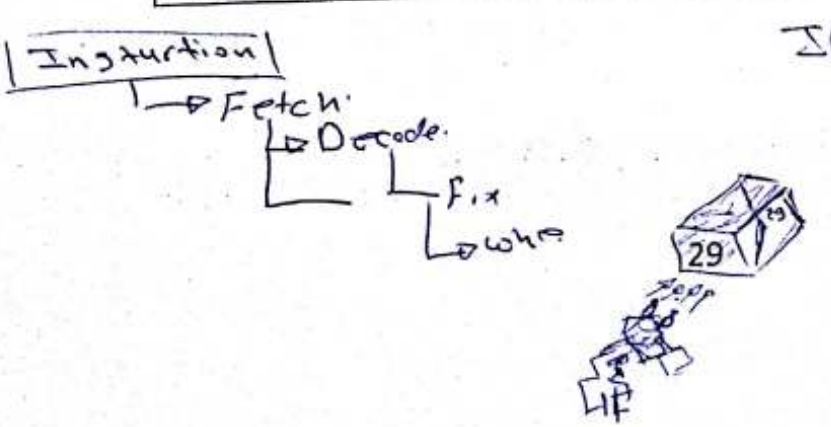
Core i7

L3 cache on-die

The Microprocessor Age:

The fist microprocessor was developed at Intel Corporation in 1971. Table-1 lists the early and modern Intel microprocessor.

Type Number	Speed	Addressing memory	word	Number of instructions
4004	0.2M Hz	4K nibble	4	45
8008	0.2M Hz	16K byte	8	48
8080	2M Hz	64k byte	8	246
8085	3M Hz	64k byte	8	246
8086	5M Hz	1M byte	16	Over 20000
8088	5M Hz	1M byte	8	Over 20000
80186	6-20MHz	1M byte	16	Over 20000
80188	6-20MHz	1M byte	8	Over 20000
80286	8M Hz	16M byte	16	Over 20000
80386DX	16 M Hz	4G byte	32	Over 20000
80386EX	16 M Hz	64M byte	16	Over 20000
80386SL	16 M Hz	32M byte	16	Over 20000
80386SLC	25 M Hz	32M+1Kcache	16	Over 20000
80386SX	25 M Hz	16M byte	16	Over 20000
80486DX	66 M Hz	4G+8Kcache	32	Over 20000
80486SX	50 M Hz	4G+8Kcache	32	Over 20000
80486DX4	100M Hz	4G+16Kcache	32	Over 20000
Pentium	100M Hz	4G+8Kcache	64	Over 20000
Pentium Overdrive	120M Hz	4G+8Kcache	32	Over 20000
Pentium pro	180M Hz	64G+8K L1 cache +256K L2 cache	64	Over 20000
Pentium II	233MHz-450MHz	64G+32K L1 cache +512K L2 cache	64	Over 20000
Pentium II Xeon	400M Hz	64G+32K L1 cache +512K or 1M L2 cache	64	Over 20000
Pentium III Pentium 4	1G Hz 1.3G Hz	64G+32K L1 cache +256K L2 cache	64	Over 20000



To execute a program:

– The user enters its instructions in binary format into the memory.

– The microprocessor then reads these instructions and whatever data is needed from memory, executes the instructions and places the results either in memory or produces it on an output device.

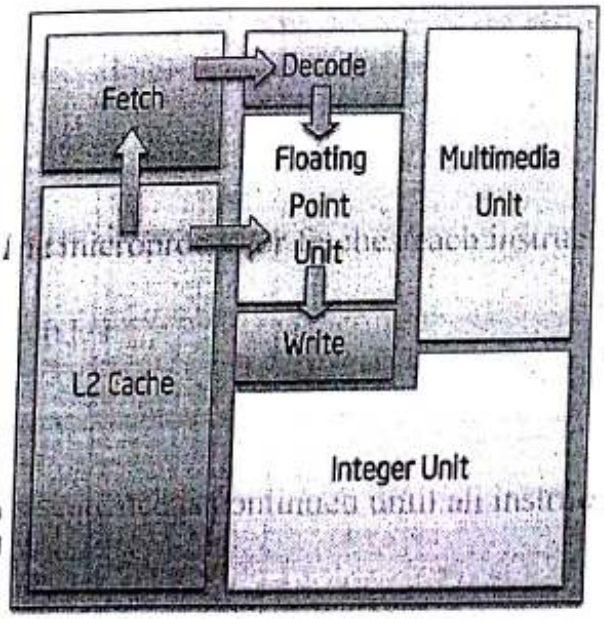
The three cycle instruction execution model

• To execute a program, the microprocessor "reads" each instruction from memory, "interprets" it, then "executes" it.

• To use the right names for the cycles:

1. The microprocessor fetches each instruction,
2. decodes it,
3. Then executes it.

• This sequence is continued until all instructions are performed.

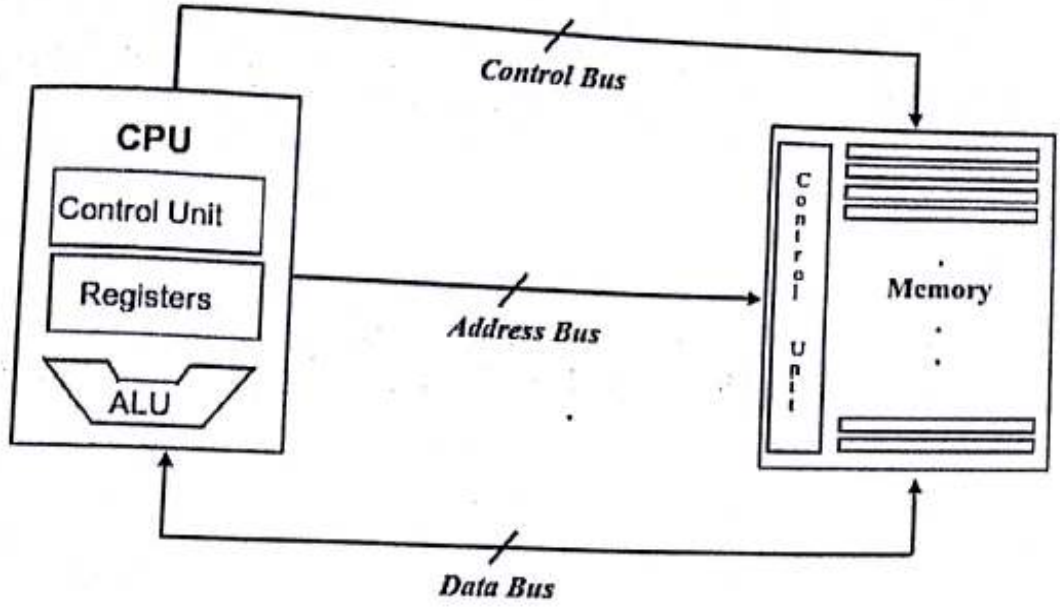


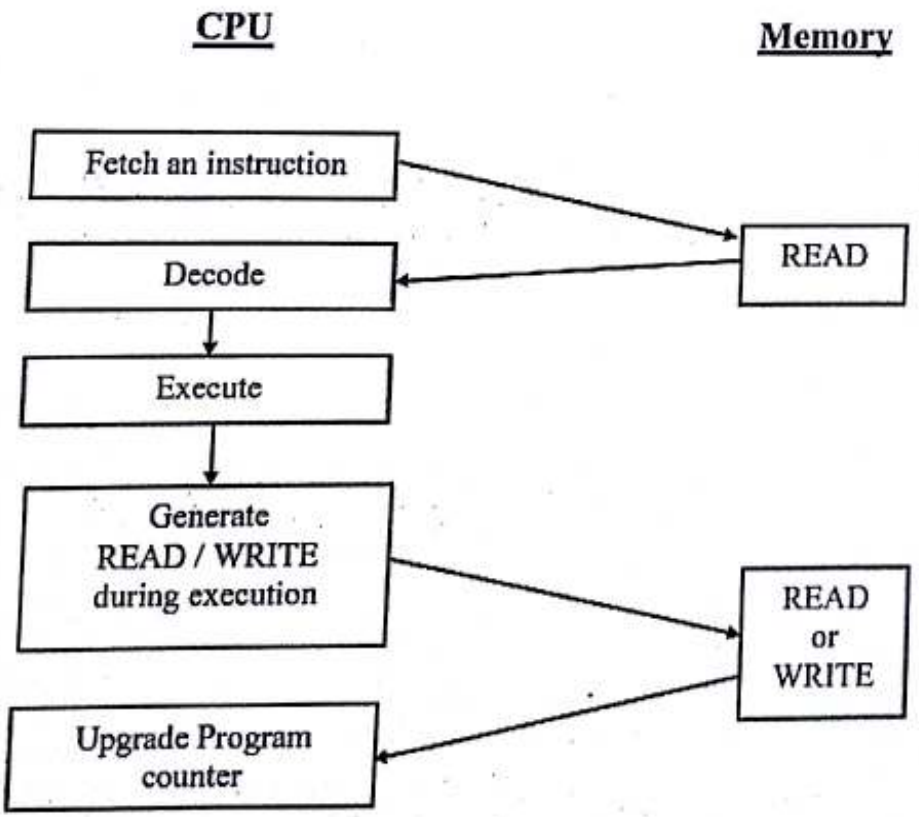
Fetch Unit gets the next instruction from the cache.

Decode Unit determines type of instruction.

Instruction and data sent to Execution Unit.

Write Unit stores result.

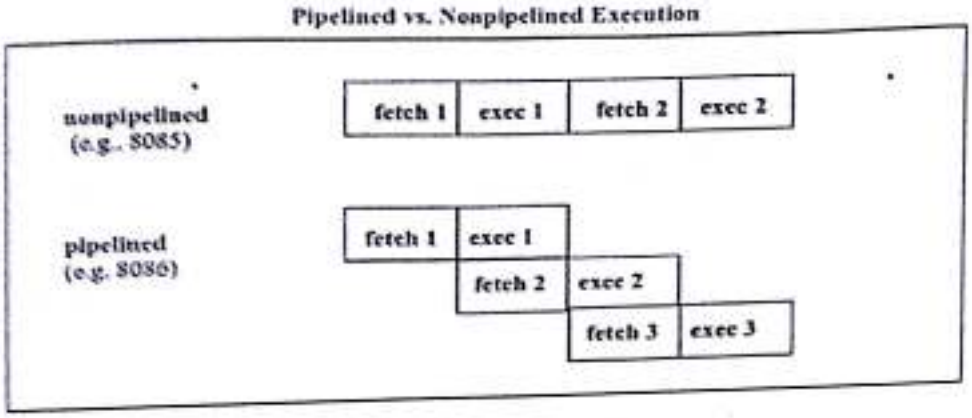




Pipelining

In the 8085 microprocessor, the CPU could either fetch or execute at a given time. CPU had to fetch an instruction from the memory, then execute it, then fetch again and execute it and so on..

Pipelining is the simplest form to allow the CPU to ***fetch*** and ***execute*** at the same time. Note that the fetch and execute times can be different.

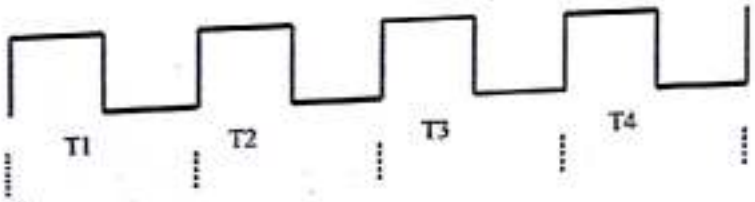


Machine cycle

Machine cycle is defined as the time required to complete one operation of accessing memory input/output, or acknowledging an external request. This cycle may consists of three to six T-states.

T-state

T-state is defined as one subdivision of operation performed in one clock period. These subdivisions are internal states synchronized with the system clock, and each T-state is precisely equal to one clock period.



Instruction cycle

The sequence of operations that a processor has to carry out while executing the instruction is called instruction cycle. Each instruction cycle of processor contains a number of machine cycles.

Fetch and execute cycle

The instruction cycle is divided in to fetch and execute cycles. The fetch cycle is executed to fetch the opcode from memory. The execute cycle is executed to decode the instruction and to perform the work instructed by the instruction.

HW#1

1. Convert each following base-R number to the equivalent base-10 number:
   a) $(100111)_2 =$
   b) $(D3A)_{16} =$
2. Convert (100) base-10 number to the equivalent number in base 2,3,16:
   base 2=
   base 3=
   base 16=
3. Given the following base-10 sign magnitude numbers: W=10, X=-18, Y = -23.
   3.1 Convert these numbers into 8-bit binary numbers using
   a) sign magnitude representation
   b) b) 2's complement representation.

	W	X	Y
Sign Magnitude			
2's compliment			

3.2 Perform the following arithmetic operations using the results from 3.1b. Assume that you can only use adder!
   a) $X - Y = X + (-Y) =$
   b) $W + X + Y =$

4- What is a microprocessor ?

5- What is A microcontroller ?

6- What is the difference between (microprocessor, microcomputer and a microcontroller) ?

7- What is the difference between assembly language and machine language?

8- Explain the MP system bus?

9- What is meant by instruction?

10- What language a microprocessor understands?

11- What are the jobs that a microcomputer is capable of doing?

12- What is meant by the term 'word'?

13- What is meant by the term 'long word'?